MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2018/2019

TIF2721 – INTRODUCTION TO FORMAL METHODS

(All sections / Groups)

29th MAY 2019
9.00 am – 11.00 am
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 4 pages with 4 Questions only, excluding the cover page.
2. Attempt ALL **FOUR** out of **FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

QUESTION (1)

(A) A formal specification language is usually composed of three primary components. What are these components? Explain briefly. [3 marks]

(B) Convert the following English sentences into predicate logic expressions.

1. There exists a smart student.
2. Every student loves some student.
3. Every student who takes Formal Methods passes it.

[3 marks]

(C) Examine the three relations below:

$relA = \{john \mapsto 51, anne \mapsto 97, tan \mapsto 42, ali \mapsto 51, bob \mapsto 44\}$
$relB = \{21 \mapsto red, 42 \mapsto black, 44 \mapsto orange\}$
$relC = \{21 \mapsto blue, 51 \mapsto green, 44 \mapsto white\}$

What are the elements of the following relations:

$relD = relA \setminus \{anne \mapsto 97\}$ *(Set difference)* [1 mark]
$relE = relB \oplus relC$ *(Relational overriding)* [2 marks]
$relF = relD \fatsemi relE$ *(Relational composition)* [2 marks]

(D) You are given two Z schemas A and B as defined below:

A
$y : 1..100$
$U : \mathbb{P}\,\mathbb{Z}$
$y \in U$

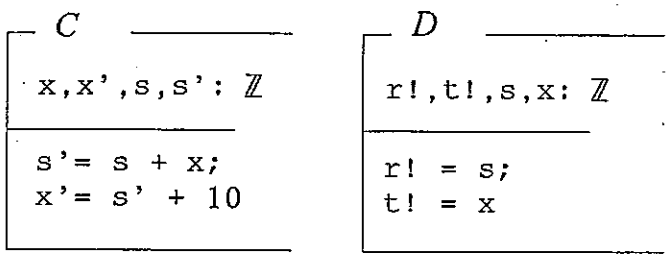
B
$y : \mathbb{N}$
$U : \mathbb{P}\,\mathbb{N}$
$y > 50$

What is $A \vee B$? Show the two necessary steps: Normalization and Linking. [4 marks]

Continue...

QUESTION (2)

(A) You are given two Z schemas *C* and *D* as defined below:



Define $C \fatsemi D$ (Schema composition *C* then *D*). Show all necessary steps. [6 marks]

(B) What is the main difference between schema composition and schema piping? [2 marks]

(C) Three sequences *A*, *B* and *C* are defined as follows:

$A = \langle 2,4,30 \rangle$
$B = \langle 66,77,88 \rangle$
$C = \langle 101,102,103 \rangle$

Find the following:

i. $(B \frown A) \frown (C \frown A)$

ii. rev $(C \frown A) \frown$ head(C)

iii. $(A \frown C)$ after 3

[3 marks]

(D) Specify a function (in Z notation) that computes the sum of all numbers in a given sequence of natural numbers. [2 marks]

(E) Specify a function (in Z notation) that computes the sum of all positive numbers in a given sequence of integers. [2 marks]

Continue...

QUESTION (3)

The following state schema *BirthdayBook* records people's birthdays in a database system.

$$
\begin{array}{|l}
\hline
BirthdayBook \\
known : \mathbb{P}\ NAME \\
birthday : NAME \pfun DATE \\
\hline
known = \mathrm{dom}\ birthday \\
\hline
\end{array}
$$

known is the set of names with birthdays recorded, *birthday* is a function which, when applied to certain names, gives the birthdays associated with them. for example:

$$known = \{ \text{John}, \text{Mike}, \text{Susan} \}$$

$$birthday = \{ \text{John} \mapsto \text{25–Mar}, \ \text{Mike} \mapsto \text{20–Dec}, \ \text{Susan} \mapsto \text{20–Dec} \}.$$

a) Define (in Z notation), the schemas Δ *BirthdayBook* and Ξ *BirthdayBook*. [4 marks]

b) Define (in Z notation), the schema *AddBirthday* to add a new birthday. The name to be added must not already be one of those known to the system. [2 marks]

c) Define (in Z notation), the schema *Success* that just produce a report such as "The new birthday has been added" in order to inform user that the operation *AddBirthday* has been successfully carried out. [1 Mark]

d) Define (in Z notation), the schema *AlreadyKnown* which describes the conditions when the name to be added is already existed and known to the system and specify an appropriate error report to be produced. [2 Marks]

e) Define (in Z notation), the schema *FindBirthday* to find the birthday of a person known to the system. [2 Marks]

f) Define (in Z notation), the schema *FindPerson* to find the name of a person using his birthday. [2 Marks]

g) Define (in Z notation), the schema *ChangeBirthday* to change the birthday of a person known to the system. [2 Marks]

Continue...

QUESTION (4)

(A) What does *Data reification* refer to in formal methods? Give a simple example. [2 marks]

(B) Prove by sequence induction that the operation of set union (U) implemented using sequences as defined by the function *append* below is correct.

$[X]$

$\text{append}: \text{seq}\, X \times \text{seq}\, X \rightarrow \text{seq}\, X$

$$\begin{aligned}
&\forall x: X;\ \sigma, \tau: \text{seq}\, X \bullet \\
&\quad (\text{append}\ (\langle\rangle, \tau) = \langle\rangle) \land \\
&\quad (x \in \text{ran}\ \tau \Longrightarrow \\
&\qquad \text{append}\ (\langle x\rangle \frown \sigma, \tau) = \text{append}\ (\sigma, \tau)) \land \\
&\quad (x \notin \text{ran}\ \tau \Longrightarrow \\
&\qquad \text{append}\ (\langle x\rangle \frown \sigma, \tau) = \langle x\rangle \frown \text{append}\ (\sigma, \tau))
\end{aligned}$$

[5 marks]

Hints: To prove that *append* correctly models (the union operator U), we have to show that: $ret(append\ (\sigma, \tau)) = (ret\ \sigma)\ U\ (ret\ \tau)$. You have to prove both the base case and the inductive step.

(C) Find the weakest precondition *P* for each of the following Hoare triples.

1. { P } x := 3 { x+y > 0 }
2. { P } x := 3*y + z { x * y - z > 0 }

[3 marks]

(D) Briefly describe the FIVE steps in the process of developing and using formal specification. [5 marks]

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